Bureau canadien de la sécurité aérienne

Canadian Aviation Safety Board

Rapport d'un fait aéronautique civil

Civil Aviation Occurrence Report

Canada

The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

HELI-PLUS INC.
HUGHES 500C (Helicopter) C-FHNN
LAC GRAND, QUEBEC
16 MAY 1987

REPORT NUMBER 87-H70001

SYNOPSIS

The helicopter was being flown at low altitude over Lac Grand when it struck unmarked wires strung between the mainland and an island. The pilot and four members of a television film crew were fatally injured when the aircraft crashed into the water immediately after striking the wires.

The Canadian Aviation Safety Board (CASB) determined that the pilot operated the aircraft at high speed and low altitude without adequate pre-planning for the flight or reconnaissance of the area.

Ce rapport est également disponible en français.

20 March 1990

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 16 May 1987, a Hughes 500C helicopter, C-FHNN, owned and operated by Heli-Plus Inc., was supporting two other company helicopters being used for sightseeing flights at sites in Gatineau and Ottawa. After the helicopter was fully fuelled at the Gatineau Airport, the pilot flew to a temporary heliport at a shopping centre in the city of Gatineau where he ascertained that the other company aircraft could cope with the existing sightseeing traffic. He then flew to the Ottawa site to confer with the company pilot operating there. While on the ground in Ottawa, he was recalled to Gatineau to take a television crew for a short local flight to obtain film footage for an upcoming Fish and Game Show.

When he returned to Gatineau, the pilot remained in the helicopter and kept its engine running while he spoke briefly with the police constable who was organizing the activities at the temporary heliport. The policeman told the pilot to be back at the heliport in five minutes because a later return would conflict with other activities at the site. Meanwhile, the television crew consisting of a soundman, a cameraman, and two announcers boarded the aircraft. The helicopter took off immediately thereafter, at about 1150 eastern daylight time (EDT)* and headed toward Hull.

At about 1158 EDT, the helicopter was seen over Lac Grand (see Appendix A - Estimated Flight Path) at about 300 feet above the surface of the lake. A videotape recovered from the wreckage showed that the helicopter flew to the north end of the lake then turned northwest to fly over the east shore of Lac MacArthur. The pilot then followed an easterly track to the eastern tip of Lac de la Montagne where a descending right turn to the southwest was completed. He levelled the aircraft at 10 to 20 feet (skid height) above the water and headed down the lake at an indicated airspeed of about 105 knots. At the end of Lac de la Montagne, he turned left to a heading of about 235 degrees magnetic** and climbed slightly to clear the trees and a cottage on the neck of land between Lac de la Montagne and Lac Grand.

* All times are EDT (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

** All units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

Once clear of the trees, the pilot again descended to about 20 feet and headed toward the bay north of Round Top and Puddington's islands. Just prior to entering the bay, a left turn was made in order to fly to the east of Puddington's Island. When abeam Puddington's Island, the pilot made a right turn and passed between Puddington's and Round Top islands. He then initiated a left turn, climbing slightly, and entered the channel between Round Top Island and the mainland. While still in the turn, at about 35 degrees of bank and in a relatively level pitch attitude, the helicopter simultaneously struck a Hydro-Québec power line and a Bell Canada telephone line which were strung across the channel (see Appendix B - Detail of Impact with Wires).

The helicopter pitched nose-up momentarily, then pitched nose-down, and rolled to the right. At this point, the videotape ended. The helicopter flew directly into the water after it struck the wires and sank immediately. Local cottagers rushed to the scene by boat but were unable to find any survivors.

The accident occurred at 1202 EDT in the hours of daylight at lat 45°40'N, long 75°39'W* at an elevation of 530 feet above sea level (asl).

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	4	-	5
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	1	4	-	5

1.3 Damage to Aircraft

The helicopter was destroyed.

1.4 Other Damage

The Hydro-Québec power line and the Bell Canada telephone line, which were attached to the same poles, were broken by the helicopter. The power line was a single phase cable for a secondary residence; it failed at the mid-point of the channel, 176 feet from the west pole and 121 feet from the east pole. The telephone line failed at the west pole.

* See Glossary for all abbreviations and acronyms.

1.5 Personnel Information

Age	37
Pilot Licence	Commercial Rotorcraft
Medical Expiry Date	01/04/88
Total Flying Time	5,600 hr (approximate)
Total on Type	60 hr (approximate)
Total Last 90 Days	90 hr (approximate)
Total on Type Last 90 Days	5 hr
Hours on Duty Prior to Occurrence	5 hr
Hours Off Duty Prior to Work Period	7 hr

The pilot received his commercial rotorcraft pilot licence on 17 August 1973, after completing the 100-hour pilot course. He was then employed as a helicopter pilot and operated from a variety of bases throughout the Province of Quebec and other parts of Canada until 1985, when he joined Heli-Plus. During this time, he was involved in the aerial application of pesticides, and he gained significant experience in low-altitude operations.

The company operated two Bell 206's, an Aerospatiale 350 and the Hughes 500. The pilot was endorsed on the three types. He received his Hughes 500 endorsement on 28 July 1985. His most recent pilot proficiency check was successfully completed 30 April 1987, on a Bell 206. He was licensed and qualified for the flight in accordance with existing regulations.

The pilot's flight experience on type is approximate and is based upon the time logged by him as pilot-in-command of the occurrence aircraft.

The pilot was the company Vice-President, the Chief of Operations and the Chief Pilot. He was also a part owner. On the day before the accident, he had completed preparations to buy the balance of the company shares in order to be the sole owner of the company.

1.6 Aircraft Information

Manufacturer	McDonnell Douglas Helicopter Company
Type	Hughes Model 500C Series 369 HS
Year of Manufacture	1974
Serial Number	140559S
Certificate of Airworthiness	Valid
Total Airframe Time	5313.7 hr
Engine Type (1)	Allison 250 C-20
Maximum Allowable Take-off Weight	2,550 lb (internal)
Recommended Fuel Type	Jet A or A-1

1.6.1 Weight and Centre of Gravity

The maximum permissible take-off weight for this model of the Hughes 500 is 2,550 pounds when the load is carried internally. The weight of the helicopter was calculated to be 2,851 pounds at the time of impact. The longitudinal centre of gravity limits are 99 to 104 inches aft of the datum at the approved weight. The longitudinal centre of gravity was calculated to be 99.4 inches aft of the datum. The lateral centre of gravity was within the prescribed limits for the approved weight (see Appendix E - Weight and Centre of Gravity Calculation).

A written record of a weight and centre of gravity calculation was not prepared for the flight. Such a record was not required either by regulation or in the company's operations manual.

1.6.2 Aircraft Documents

The aircraft documents, including the Aircraft Record Set and the Journey Log, were reviewed for accuracy, completeness, and compliance with service bulletins and Airworthiness Directives. Only minor discrepancies were noted, and all applicable Airworthiness Directives had been complied with.

1.6.3 Design of Left and Right Front-Seat Backs

The seat-back cushions in the left and right front-seat positions fit into a recessed box structure. The top horizontal member of the box structure is 24 inches above the seat base and comes to within 1.5 inches of the forward face of the seat-back cushion. The cushion can easily be compressed more than 1.5 inches.

1.6.4 Tinted Windshield

The windshield of the Hughes 500C is divided vertically into three areas. The middle section, which extends from near knee level to above head height, is lightly tinted. The tint had little or no effect on visibility, even in reduced light conditions. The upper and lower windshield sections are tinted a darker colour, but these were not in the pilot's line of sight as the helicopter approached the wires.

1.7 Meteorological Information

The reported weather for 1200 EDT at the Gatineau Airport, 12 miles south of Lac Grand, was scattered clouds at 10,000 feet asl and 26,000 feet asl; visibility 15 miles; wind 220 degrees true at 12 knots; and temperature 13 degrees Celsius.

1.8 Aids to Navigation

No radio navigation aids were required or used for the flight.

Several topographical maps were found; however, the manner in which they were folded indicated that they were not in use at the time of the wirestrike. The pilot was familiar with the area having operated locally for some time. As well, he had flown a local real estate developer to a site 700 metres north of the accident site twice in recent months.

1.9 Communications

Not pertinent.

1.10 Aerodrome Information

Not pertinent.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

There were two impacts, the first with the wires and the second with the water. It was determined that the aircraft was in an approximate 35-degree left bank turn when it struck the wires (see Appendix B - Detail of Impact with Wires). The overall damage pattern indicated that the aircraft struck the water at a high forward speed and moderate vertical speed. It was estimated that the aircraft struck the water in a 20-degree nose-down attitude with 20 degrees of left bank. There was also evidence that the aircraft was yawing or slipping to the left.

1.12.1 Aircraft Damage

There was no evidence of a pre-impact airframe failure or engine malfunction. The damage to the axial compressor section of the engine showed that the compressor was still rotating when airframe distortion, which occurred as a result of the water impact, broke the air intake. There was minimal internal damage to the engine, and, therefore, engine rotational speed could not be determined.

The shaft between the engine and the main transmission failed as a result of torsional overload, indicating that the engine was producing power when the rotor system was suddenly decelerated.

A black rub mark on the left-front landing gear leg was assessed as having been caused by the telephone wire. The lower portion of the leg contacted the wire which then slid up to the step area and broke.

There was no evidence that the power line was struck by the front fuselage frame or the engine intake leading edges, thus indicating that the initial contact was directly into the main rotor swash plate area. There was evidence of wire contact on two of the main rotor blades, but it could not be determined whether this occurred before or after the wire was engaged by the hub. The wire was snagged by the arms of the rotating swash plate early in the sequence and was wrapped around the rotor head. This action pulled, then broke all the main rotor blade pitch control rods, severing collective and cyclic pitch control. When the pitch control rods failed, the helicopter became uncontrollable.

The aircraft systems examination did not reveal any fault which might have affected or limited control of the aircraft prior to contact with the wires. All damage to the controls and drives is consistent with that expected from the wire strike, the wind-up of the wire on the main rotor assembly, and the water impact.

1.12.2 Impact Site

Investigators completed an aerial examination of the accident site from a helicopter and noted that the buildings on Round Top Island are at the south end, or opposite side of the island from the occurrence helicopter's final approach path. Also, the cottages on the mainland are hidden in the trees. The supporting poles, at both ends of the lines, are surrounded by taller trees and are set well back from the shore (see Appendices B and C). Because of the types of trees, the orientation of the channel, the slope of the nearby terrain, and the shade in the channel at noon, the unmarked wires were difficult to see. There are boathouses on the southwestern side of Round Top Island and these are visible when flying in a northerly direction up Lac Grand.

The helicopter struck the wires at the mid-point of the channel. Appendix B is based upon a computer reconstruction of factual evidence obtained from the site survey, videotape, and divers' wreckage sketches. It shows that the aircraft was about seven metres, or 23 feet, above the surface of the water at this time.

1.13 Medical Information

There was no evidence that incapacitation or physiological factors affected the pilot's performance.

The pilot's most recent medical examination was completed in March 1987, and he held a current Licence Validation Certificate endorsed with a Category 1 medical. His eyesight tested at 20/16 in both eyes, and he did not require glasses. He completed the colour vision test without error. During the 72 hours preceding the accident, the pilot's work load and nutrition were normal, and he had had adequate rest.

1.14 Fire

There was no evidence of fire either before or after the occurrence.

1.15 Survival Aspects

An autopsy was completed on the pilot but not on the other aircraft occupants. The pilot's death was attributed to a ruptured aorta, possibly following a large impact to his upper back and complete rupture of the spine. The spinal injury was about 24 inches high on his back. The right front-seat passenger suffered a spinal injury at about the same height.

The stated causes of death for the other aircraft occupants were as follows: the right front-seat occupant - probable drowning, skull and spinal fractures; the centre front-seat occupant - probable drowning, asphyxiation due to aspiration of water; and both occupants in the back seat - probable drowning although one suffered a major trauma to the thorax and the other suffered a trauma to the cranium.

The aircraft occupants were all using lap belts, and, except for the right front belt, all the lap belts failed. Shoulder harnesses were available at the two front cockpit positions but were not worn. Shoulder harnesses were not required under current regulations. To determine the deceleration forces experienced during the crash, the impact sequence, aircraft damage, personal injuries, and lap belt failures were studied. Laboratory tests showed that the lap belts failed when subjected to a tensile force of 2,100 pounds; assuming an average occupant weight of 175 pounds, a deceleration force of at least 12G would be required to break the belt. As one belt did not fail, it was concluded that the horizontal deceleration forces were in fact about 12G. This force is within the generally accepted range for survivable impacts if proper restraints are used.

The lap belt anchor for the left front seat failed as a result of extensive local structural damage caused by the impact. The other belts failed because the belt webs were overloaded. Tensile strength tests of two samples of belt webbing confirmed the acceptability of the belts in accordance with existing requirements. Shoulder harnesses were available at the left and right front seats, but neither was used. The aircraft was not equipped with life-jackets, and the occupants were not wearing head protection, nor were they required to do so.

It was not determined whether all the aircraft's occupants were required to be on board for the filming exercise; however, it was found that the number of people carried on board an aircraft during low-altitude

special-purpose operations is not restricted by regulation or company policy to those persons essential to the operation.

1.16 Tests and Research

1.16.1 Psychological Factors Analysis

A psychologist, at the request of the CASB, completed a psychological factors analysis which focused on the pilot's normal work habits, his emotional well-being, and his ability to deal with stress. Life-style stresses, work-related stresses, and stress related to the occurrence were examined including local stresses such as fatigue leading to lapses in concentration or pressure from the customer to carry out high-risk activities.

The analyst concluded that there were no predisposing factors which would have caused the pilot to change his flying habits. The assumption of sole ownership of the company was identified as a major change in the pilot's life but was assessed as being well within his capacities.

The analyst could not ascertain whether there was pressure on the pilot from the television crew to carry out the low-level flight. He noted that any commercial helicopter pilot is likely to experience some role conflict from time to time between his responsibility as a pilot and the need to please clients to ensure commercial success and that this conflict may be particularly sharp when the pilot is also a senior executive or part owner of the company.

The pilot had agreed initially to limit the flight to a duration of five minutes; however, a longer flight was carried out. The analyst stated that the pilot may have experienced some pressure as a result, and he concluded that this could have led to a momentary lapse of concentration.

1.16.2 Customer Survey

A customer survey was completed of persons who had flown with the pilot during his tenure with Heli-Plus. Those interviewed were asked if the pilot had carried out any low-flying operations in their presence and, if so, under what circumstances. It was determined that the pilot did not conduct unsolicited low flying and that, on occasion, he had refused to low fly when asked if it was not required for the operation and/or it was contrary to regulations. When required to fly at

altitudes of 100 feet above ground level (agl) or below, he completed a thorough aerial reconnaissance first, then carried out the exercise at very low airspeed. There was also evidence that he was conscious of wires and similar hazards to low-flying aircraft. On one occasion, just a few days prior to the accident, he reportedly pointed out the hazards of low flying near an island in an area where cottages had been built.

1.16.3 Videotape Evidence

A videotape made by the television crew was recovered from the lake at the accident site. It was taken to the National Research Council Laboratory in Ottawa where it was dried and prepared for viewing. The tape showed the flight path as previously indicated.

The CASB Engineering Laboratory enhanced the videotape to extract any evidence and to reproduce the flight path using computer simulation and mapping. (Appendices A to C were developed in the computer simulation and mapping project.) After the enhancing process, the tape was again reviewed. Aircraft airspeed, altitude, and attitude were estimated, but no usable voice audio was obtained. The tape also supported the conclusions of the wreckage examination. It was also noted from the tape that the wires were not visible during the flight north at higher altitude nor during the low-altitude run; the boathouses on the southwestern side of Round Top Island were visible.

1.17 Additional Information

1.17.1 Pertinent Regulations

The helicopter was on an aerial photography flight as defined by the existing Air Regulation 534 respecting minimum flight altitudes, and Air Navigation Order (ANO) Series II, Number 2, the Aircraft Seats, Safety Belts and Safety Harnesses Order. At present, the Air Regulation removes all altitude and clearance minima for special-purpose operations provided they can be completed without creating a hazard to persons or property. According to the ANO, aircraft employed on special-purpose operations shall be equipped with a seat and an individual safety harness for each person. The pilot shall wear his seat-belt or safety harness at all times, and the passengers shall do so when directed by the pilot. The ANO does not specifically direct the passengers to wear shoulder harnesses during low-altitude special-purpose operations.

ANO Series II, Number 8, the Life-Saving Equipment Order, required at the time of the accident that any single-engined aircraft operating beyond gliding distance from shore be equipped with a life-jacket for each person on board.

1.17.2 Aerial Reconnaissance

Prior to flying at low altitudes in order to land or carry out some special-purpose operation, an aerial reconnaissance of the site should be completed. Several cottagers in the Lac Grand area observed the helicopter at various stages of its flight. There were no reports that the helicopter performed a low-altitude flight at low speed near or over the accident site that morning.

1.17.3 Wire-Marking Requirements

Two Acts of Parliament governing wire marking are pertinent to this accident: the Navigable Waters Protection Act (NWPA), which is administered by the Canadian Coast Guard Organization of Transport Canada; and the Aeronautics Act, which is administered by Transport Canada Aviation Group.

The NWPA applies to water traffic only and states that approval by the Minister of Transport is required before a wire is installed over navigable waters. Neither Hydro-Quebec nor Bell Telephone applied for approval by the Minister of Transport before installing their respective lines between Round Top Island and the shore. Bell Canada installed its wire after the Hydro-Quebec wire was already in place. Hydro-Quebec is a Quebec Provincial Crown Corporation and abides by the Provincial interpretation of the NWPA. This interpretation equates navigable waterway to those waterways which are used for commercial navigation only. The federal government (and Tansport Canada) applies the act to both commercial and recreational waterways.

A standard for Overhead Systems, approved by the Canadian Standards Association, was published in April 1987. This standard has been developed to protect marine traffic. Wire crossings over navigable waters require approval by the Federal Minister of Transport. Obstruction markings of wires, conductors, and structures are not covered in the standard. No published Transport Canada guidelines or standards specify the conditions and criteria governing the markings to be used for marking overhead lines approved under the NWPA. After a request for approval is

submitted to Transport Canada, the crossing in consideration is inspected by the Canadian Coast Guard Regional Inspector who then determines whether the water is navigable at the particular site and, if so, what the conditions would be for approval. Such conditions could include appropriate markings; each case is studied on its merits. As well, all applications for overhead lines are referred to the appropriate Aviation Group Regional Office for review with respect to recommendations for air navigational line markings.

On 02 June 1987, after the accident, the Regional Chief, Navigable Waters Program, Laurention Region Coast Guard, reported that Lac Grand was navigable at the accident site. He recommended a minimum vertical clearance of 12.2 metres and marking of the wires with yellow sleeve markers. He also stated that the power line, which had been reinstalled at the same height and in the same location, could create a hazard to public surface water navigation because of its low vertical clearance and its lack of markings.

At the time of the original installation of the Hydro-Quebec wires, it was not the policy of Hydro-Quebec to use sleeve markers; thus, the inclusion of sleeve markers would not have formed part of their application to install the wires. Staff of the Canadian Coast Guard Laurention Regional Office and Hydro-Québec have developed a verbal agreement that markers to be used, when required, would be internationally recognized shore markers and/or yellow sleeves fitted over the wires at intervals.

It was determined that under the Aeronautics Act there were no marking requirements for the wires struck in this accident. For example, the site was not near a sea-plane landing area, nor were the wires sufficiently high to pose a hazard to overflying aircraft.

1.17.4 Conspicuousness of Wires

It was confirmed during a helicopter flight to reconstruct the occurrence flight that unmarked wires in the Lac Grand area are difficult to see because of the type and colour of the background terrain and vegetation. Several examples of wires marked with yellow sleeves were examined, and it was found that the sleeves significantly enhanced the conspicuousness of the wires.

It is generally known that wires are hard to see, and, consequently, a number of other factors are used to indicate the possible presence of wires. Supporting poles, roads, a large number of buildings, or buildings on islands are all indicators of wire crossings. None of these indicators was visible to the pilot on his final approach path, although the boathouses would have been clearly visible during the initial flight north.

1.17.5 Repair of the Power Line

The power line was repaired by Hydro-Québec prior to the arrival of the CASB investigators and before obtaining a release to do so from the CASB. Several small pieces of the old line were removed. A record of the condition of the occurrence site and of the subsequent actions was not provided. Section 7 of the Canadian Aviation Safety Board Regulations states in part that no person shall disrupt an occurrence site, except to resolve a dangerous situation, unless an investigator has given the person permission to do so. If the site is disturbed for safety reasons, the person is to make a record of the condition of the occurrence site if possible.

1.17.6 Wire-Strike Protection Systems

A wire-strike protection system (WSPS) is available for the Hughes 500C aircraft under approved supplementary type certificate SH122750 (see Appendix D - Detail of WSPS Installation). The system is engineered to prevent entry of a wire into the cockpit area, reduce the possibility of flight-control damage during a wire strike, and decrease the chance of wires becoming entangled in the landing gear. The WSPS manufacturer states that it is effective at approach angles up to 45 degrees of the wire, at speeds as low as five miles per hour, and against multiple wire strikes.

The system comprises three components, an upper and a lower cutter/deflector and a windshield deflector/guide. Each is equipped with a high tensile steel sawtooth edge. The windshield deflector/guide serves to move the wire smoothly over the cockpit area and into the cutters. The kit weighs 19.7 pounds, and the change in centre of gravity after installation is insignificant.

According to the manufacturer, any wire which passes below the arc of the main rotor when the helicopter is in forward flight will be engaged by the cutters.

However, it should be noted that wires which pass below the tip of the lower cutter may engage the skids if the aircraft attitude is sufficiently nose-down and/or the aircraft is equipped with high-skid gear, as this helicopter was.

The helicopter was not equipped with a WSPS, and none was required by regulation for this type of operation.

2.0 ANALYSIS

2.1 Introduction

It was determined early in the investigation that the helicopter had been flown at high speed and low altitude over the lake and that it crashed into the lake because it struck wires and not as a result of some other failure. The major objectives of the investigation were to establish why the pilot conducted the flight in this manner and to determine if there were any deficiencies with regard to wire-strike prevention, crashworthiness, and regulatory requirements.

2.2 Conduct of the Flight

2.2.1 Aerial Reconnaissance

The pilot was familiar with the area around the accident site; he had recently flown to a site about 2,300 feet north of the accident site, and he overflew the Lac Grand at 300 to 500 feet while transiting to the north during the occurrence flight. As well, he was an experienced low-altitude pilot. The customer survey demonstrated that the pilot was fully aware of the risks of striking wires while flying at low altitude and, consequently, fully aware of the requirement for a low-speed reconnaissance before a high-speed, low-altitude flight. However, before conducting the high-speed, low-altitude accident flight, the pilot did not conduct the precautionary low-speed reconnaissance which would have been warranted in the circumstances.

The possibility that the pilot conducted some kind of reconnaissance of the accident site area during the transit to the north was considered. This possibility was rejected, however, because the boathouses on the southwestern side of the island would have been visible to the pilot at that time.

2.2.2 Pilot Decisions

There was no evidence that prior arrangements had been made for the flight. When the helicopter was recalled for the flight, the pilot remained in the aircraft and spoke only to the police site organizer. He did not leave the aircraft or consult with anyone else on the ground, including his company representative. There was insufficient time on the ground for detailed discussion with the television crew as to the route

which would be flown for the filming. The fact that the pilot took off at a weight approximately 300 pounds above the maximum permissible take-off weight is indicative that the normally prudent pilot did not use good judgment on this occasion.

Given the pilot's local knowledge, it would not have been unusual for him to embark on this type of operation with only a general plan for the flight; his discussion with the police constable may well have influenced him to depart quickly. Such an approach would, however, have dictated careful airborne planning and reconnaissance at the filming site if a high-speed, low-altitude flight was contemplated.

It was found that, considering the weather, altitude, and aircraft weight, the helicopter was flying at near its maximum speed just prior to the wire strike. The customer survey established that the pilot was not inclined to conduct high-speed flight at low altitude and that he had refused to do so previously when asked by customers. It could not be determined whether or not the pilot was responding to pressure to carry out the low-altitude flight, nor if he was attempting to complete the filming quickly in order to get back to the shopping centre. It was concluded that the decision to fly at high speed and low altitude through an area which he had not previously surveyed was not characteristic behaviour for the pilot.

The psychological factors analysis found no evidence of predisposing stress or other factors which would have influenced the pilot to change his flying habits. The study also found that the stresses of purchasing the company and his other responsibilities were within his capacities. Consequently, it was concluded that the decision to low fly was made spontaneously.

2.3 Conspicuousness of Wires

The flight survey of the site made during the investigation established that the wires struck by the helicopter blended with the background and were not conspicuous. It was also established that, although the wires or their supporting poles would likely have been seen by a helicopter pilot conducting a careful low-altitude, low-speed survey of the area, they could not be spotted easily by the pilot of an aircraft overflying them at cruise speed at a height of 300 to 500 feet agl. Only the boathouses on the southwestern side of the island were readily detectable. The survey found that there was no obvious indication of the wires, either on the nearby shores or on the wires themselves, which could have been seen by the pilot of an aircraft entering or about to enter the channel.

The Province of Quebec interpreted the NWPA as applying to commercial waterways only, and, as a consequence, Hydro-Quebec, which followed this interpretation, would not have been required to include markings with the installation of the wires. If, as contended by the Canadian Coast Guard, some type of marking had been required, its primary purpose would not have been air navigation safety. However, on the helicopter's line of approach, a shore marker at the mainland end of the wire would have been visible to the pilot for several seconds prior to his turning left to pass through the channel between Round Top Island and the mainland. As well, sleeve markers would have made the wires more visible from the air. Consequently, it was concluded that, although the purpose of the NWPA is to protect water traffic from hazards, markings recommended under this legislation would have enhanced aviation safety through improved wire conspicuousness.

2.4 Wire-Strike Protection Systems

The technical investigation found no evidence that the power line had contacted any portion of the fuselage or engine covers. It was determined that the wire entered the rotor system directly, having first passed through the rotor disc. As a result, it was concluded that a WSPS would not likely have engaged the power line. As well, the helicopter was equipped with high skid gear, and, because the aircraft was in a nose-level banked attitude, a WSPS may not have engaged the telephone wire.

2.5 Survival Factors

Because autopsies were not conducted on four of the five occupants of the helicopter, conclusions about the effectiveness of life-jackets and head protection or if the accident was survivable could not be made with certainty. However, it was determined that, had the available shoulder harnesses been used, the severity of some injuries would have been reduced. This is particularly evident in the case of the pilot, whose injuries probably resulted from the lack of upper body forward and rearward restraint. The medical investigation noted the similarity of the heights of back injuries to both the pilot and the right front-seat passenger and the height of the seat backs.

It was not determined whether all the persons carried were required to be on board to complete the operation. At the time of the occurrence, there were no regulations or advisories to limit the number of persons carried on board an aircraft during

low-altitude special-purpose operations. Because of the increased hazards implicit in these operations, it is desirable that operators limit the number of personnel carried in the aircraft to those essential to the completion of the operation.

2.6 Aircraft Weight

The aircraft weight at the time of the accident was determined to be about 300 pounds in excess of the maximum allowable take-off weight. This overweight condition is not considered to be contributory to the accident.

2.7 Summary

There was no evidence found that prior arrangements were made for the flight or that the pilot conferred with the television crew prior to departure. This lack of detailed planning could have been offset by careful airborne planning and reconnaissance at the filming site. The pilot was experienced in low-altitude operations and customarily reconnoitered an area before attempting a low-altitude flight. Although boathouses on the southwestern side of the island were visible during the flight north up Lac Grand, it would appear that the pilot had not seen them. The reasons for the uncharacteristic decision to carry out the low-altitude flight without first taking his customary precautions could not be established.

The wires were not conspicuous because of their location. It was found that there was no requirement to mark the wires for aviation purposes. However, it was determined that, had the wires been marked for the protection of water traffic, these markings would have been visible at one point on the aircraft final flight path.

The helicopter engaged both wires in a way that a wire strike protection system would not likely have functioned. The pitch links in the rotor system failed when the hydro wire was wound in, and, as a result, the aircraft became uncontrollable and crashed.

An autopsy was completed for the pilot only, and, as a result, survivability issues for the other occupants, such as the use of shoulder harnesses, life-jackets, or helmets could not be addressed with certainty. A correlation was noted between the height of the seat backs at the right and left front-seat positions and the back injuries suffered by the pilot and possibly the right front-seat occupant.

The investigation did not determine if all the occupants of the aircraft were required to be on board. However, it was determined that the number carried was not limited by regulation to essential persons only.

3.0 CONCLUSIONS

3.1 Findings

1. The helicopter struck telephone and hydro wires while in high-speed, low-altitude controlled flight.

2. The wires were not marked, nor were they conspicuous from the air; there was no requirement to mark the wires for aviation purposes.

3. The main rotor pitch controls were damaged by the hydro wire, and, as a result, the helicopter became uncontrollable and crashed.

4. The flight was initiated without detailed pre-planning.

5. It is probable that the decision to conduct the low-altitude high-speed portion of the flight was made spontaneously.

6. The pilot did not perform an adequate aerial reconnaissance of the area.

7. The pilot's decisions and actions were uncharacteristic, and there was no conclusive evidence of predisposing stress or other psychological factors which might have led to his actions.

8. Hydro-Quebec followed the Quebec Provincial interpretation of the Navigable Waters Protection Act (NWPA) which did not require the marking of wires across recreational waterways.

9. Marking the wires as recommended under the NWPA would have improved the conspicuousness of the wires.

10. The operator was licensed and certified for the flight.

11. The pilot was licensed and qualified for the flight in accordance with existing regulations.

12. There was no evidence found of any airframe failure or system malfunction prior to or during the flight.

13. The aircraft was about 300 pounds over the maximum allowable gross weight.

14. The use of the available shoulder harnesses would have reduced the severity of some injuries.

15. The aircraft was not equipped with the life-jackets required for flight over water beyond gliding distance to shore.

16. Existing regulations do not require all aircraft occupants to wear shoulder harnesses during low-altitude special-purpose operations.

17. It was not determined whether all the persons carried were required to be on board to complete the operation.

3.2 Causes

The pilot operated the aircraft at high speed and low altitude without adequate pre-planning for the flight or reconnaissance of the area.

4.0 SAFETY ACTION

4.1 Action Required

4.1.1 Wire-Strike Protection System (WSPS)

This accident has again highlighted the hazard of operating helicopters at low-level in the vicinity of electrical or communication wires. The Canadian civilian helicopter community has experienced 65 accidents/incidents involving wire strikes between 1976 and 1988. These have resulted in 17 deaths and 10 serious injuries.

In 1981, a National Aeronautics and Space Administration (NASA) sponsored study of American civil helicopter wire strikes involving 208 occurrences, during 1970-1979, suggested that a WSPS would have been effective or potentially effective in 50 per cent of the strikes reported, of questionable effectiveness in an additional 15 per cent, and judged to be not potentially effective in the remaining 35 per cent. In this accident, a WSPS would probably not have been effective.

The wire-strike protection systems are available for a wide range of commercial helicopters. Growing acceptance of the WSPS is demonstrated by the incorporation of the system into the inventory of military aircraft in various countries, federally and provincially owned aircraft, law enforcement agencies, and a wide range of civilian operations. Approximately 10,000 WSPS kits have been contracted for and/or delivered to date.

Since 1980, Canadian Forces helicopters have encountered 12 wire strikes; in nine strikes, the wire was engaged by the WSPS, and the helicopter suffered no major damage. In two strikes, the wire was cut by the main rotor, and the helicopter suffered no significant damage. In only one wire-strike case involving a Canadian Forces helicopter equipped with the WSPS was the aircraft destroyed. The U.S. army has experienced similar success with the WSPS.

Since helicopters involved in low-level special-purpose operations remain especially vulnerable to wire strikes, and since the WSPS currently on the market has

proven its value in reducing the consequences of wire strikes, the CASB recommends that:

The Department of Transport:

a) energetically promote the fitment of wire-strike protection systems on all helicopters engaged in low-level special-purpose operations; and

b) develop appropriate legislation requiring the mandatory fitment of such equipment.

CASB 90-50

4.1.2 Low-Level Operations

The percentage of aircraft accidents during low-level operations reflect the high risk factor associated with these operations. Inadvertent impact with the ground, water, trees, wires, poles, and other natural or man-made obstacles are a constant threat. The margin for error in pilot decisions, judgement, or technique is reduced to a minimum.

An emergency at low altitude allows insufficient time for crew and passenger preparation such as bracing, fastening of shoulder harnesses, and donning of life-jackets or other life-saving protective equipment. Despite the greater probability and inherent dangers in low-level operations, current regulations make little provision for these increased risk levels.

4.1.2.1 Shoulder Harnesses

The CASB notes the action taken by Transport Canada through revisions to the Order respecting Aircraft Seats, Safety Belts and Safety Harnesses (ANO Series II, No 2) which states in part:

a) No person shall operate an aircraft on a special-purpose operation unless it is equipped with an approved seat and an approved individual safety belt, consisting of a lap strap with a shoulder harness, for each person on board the aircraft; and

b) Every person carried on board an aircraft shall keep a safety belt, including the shoulder harness, if any, properly fastened about him while the aircraft is taxiing, taking off or landing, and at any other time when so directed by a crew member or a safety-belt sign is displayed in the aircraft.

It is the Board's view that the risk of an accident occurring to an aircraft involved in a low-level special-purpose operation is increased significantly enough to warrant additional precautions regarding the use of upper-body restraint systems. The revised ANO Series II, No. 2, as presently worded, does not provide specific instructions about when a crew member should direct the wearing of a seat-belt and shoulder harness, other than for taxi, take-off, and landing. Hence, it is believed that the order would be ineffective in ensuring their use during actual low-level operations, when the aircraft is highly vulnerable. Therefore, the Board recommends that:

> The Department of Transport require that seat-belts and shoulder harnesses be worn at all times by all aircraft occupants during low-level special-purpose operations, except that the shoulder harness need not be fastened if that person would be unable to perform required duties with the shoulder harness fastened.

CASB 90-51

4.1.2.2 Passengers - Special-Purpose Operations

Air Regulation 534, defines a special-purpose operation as "an operation in which an aircraft is flown for the purpose of spraying, dusting, seeding, crop fertilizing, inspection of crops or livestock, pipeline or powerline patrolling, aerial photography and survey or other operation of a similar nature and also includes helicopter external cargo operations and pilot training."

The carrying of non-essential passengers on such high-risk, low-level specialty operations unnecessarily exposes additional persons to the dangers inherent in such operations. In the United States, the carriage of persons on such special-purpose operations is regulated by FAR 91.39 which restricts the carriage of passengers to flight crew members, flight crew members under training, and persons performing an essential function in connection with the special-purpose operation.

In Canada, Air Navigation Order (ANO) Series II, No. 2, recognizes the inherent danger and prohibits the carrying of infants and children on such flights; however, adult passengers may be unnecessarily exposed

to the added risk of low-level special-purpose operations. Therefore the Board recommends that:

> The Department of Transport discourage the carriage of non-essential personnel on special-purpose operations.

CASB 90-52

4.2 Safety Concerns

4.2.1 Pilot Decision-Making

This accident provides another disturbing example of an experienced pilot who operated his aircraft without his usual careful attention to pre-flight preparation and in-flight safety precautions.

The percentage of aircraft accidents attributable, wholly or in part, to pilot judgment is alarmingly high. While no Canadian statistics are available, the Federal Aviation Administration (FAA) Office of Aviation Medicine has estimated that 52 per cent of fatal and 35 per cent of non-fatal accidents involve pilot judgment errors. FAA research suggests that a possible explanation for this is that traditional pilot-training programs stress the acquisition of flying skills, while regarding judgment or decision-making as an off-shoot of flying experience.

This perceived deficiency in pilot training has been recognized by Transport Canada which is in the process of introducing pilot decision-making training in the private and commercial pilot training syllabi. This training program is the result of an international effort begun in 1978 to improve pilot-decision making capabilities. The concept has been jointly evaluated by Transport Canada and the FAA with encouraging results. The Board fully supports this innovative approach to the pilot-training process and will be following the progress of its implementation and effectiveness with interest.

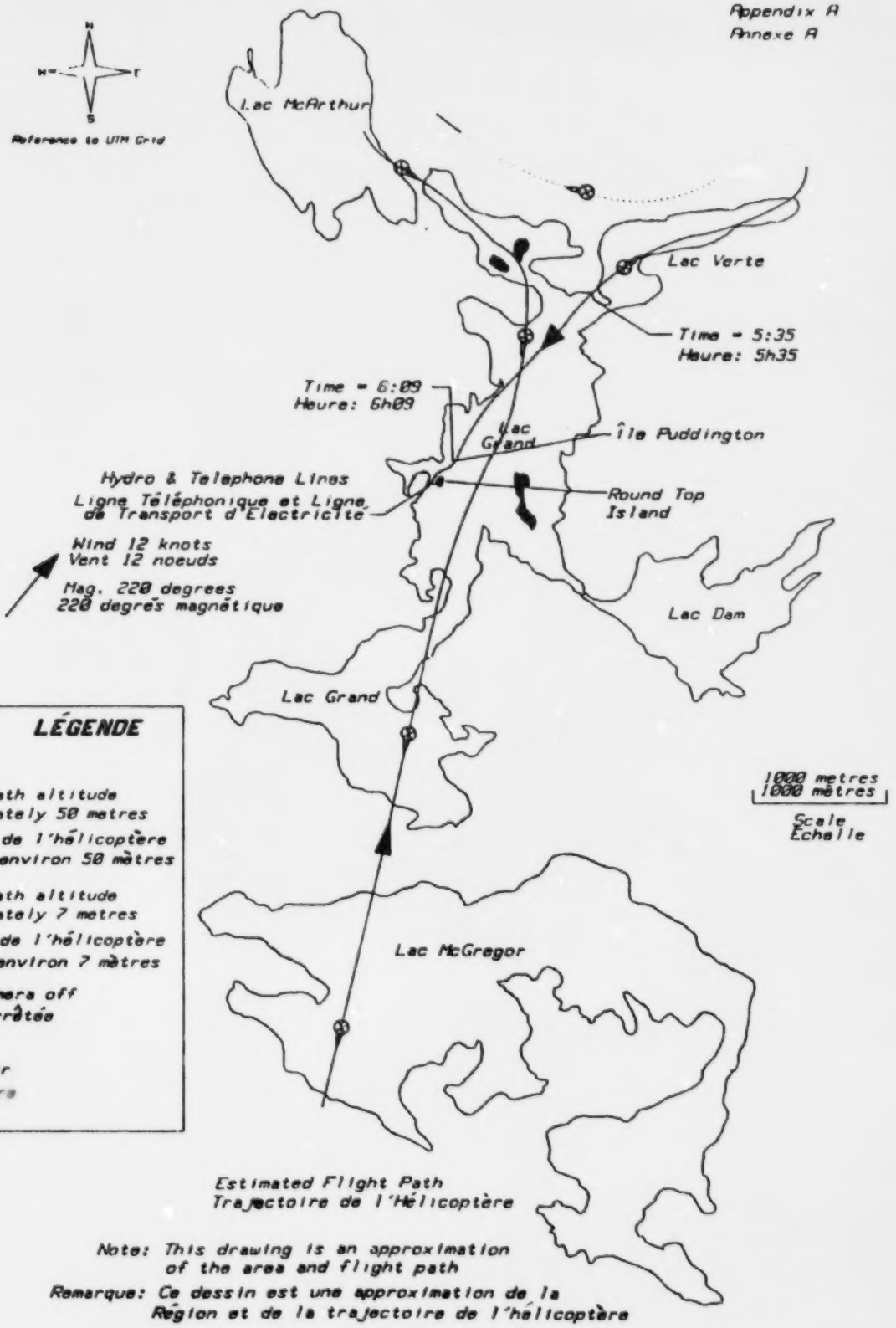
4.2.2 Aircraft Overloading

Although the aircraft's overloaded condition was determined not to have been causal to the accident, this occurrence underlines the frequent number of occurrences investigated by the CASB in which aircraft were being operated above their designed maximum permissible weight. The Board notes that Transport Canada has initiated a national aviation safety campaign which has as its main theme the hazards of

improper aircraft loading, with particular emphasis on overloading and the proper security of aircraft loads. Because the problem of overloading has persisted, Transport Canada is encouraged to vigorously continue its campaign; indeed, new initiatives may be required. The CASB will continue to monitor this campaign for its effectiveness in reducing the frequency of occurrences involving improper aircraft weight and balance.

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

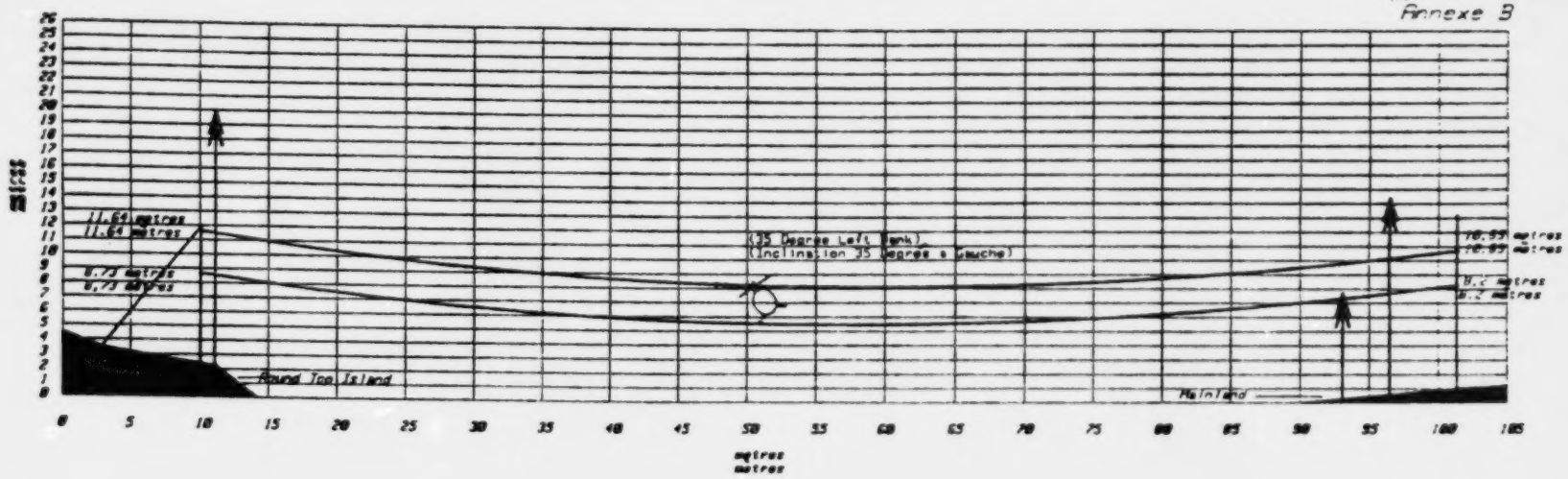
N. Bobbitt
L. Filotas
W. MacEachern
D. Mussallem
A. Portelance
B. Pultz
R. Stevenson
F. Thurston

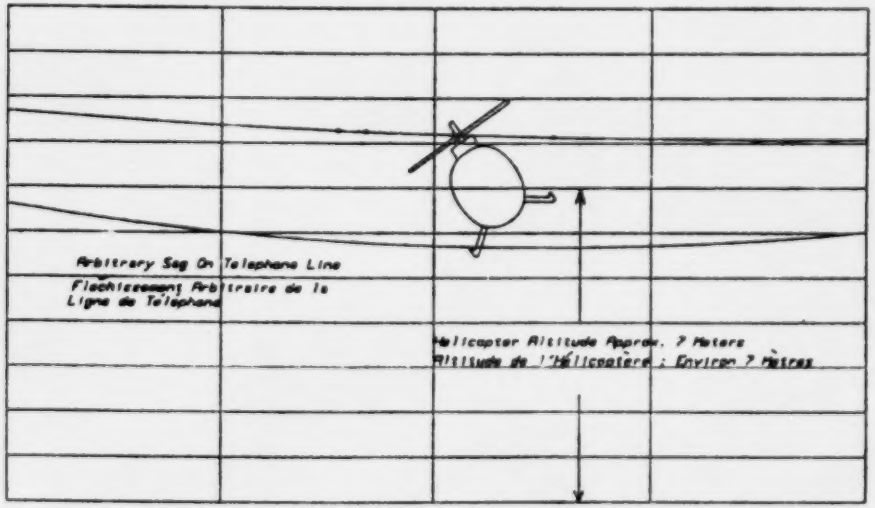


Note: This drawing is an approximation of the area and flight path

Remarque: Ce dessin est une approximation de la Région et de la trajectoire de l'hélicoptère

Derived From Figure 1 of Engineering Project LP89/87
Tiré de la Figure 1 du Projet d'Ingénierie LP 89/87

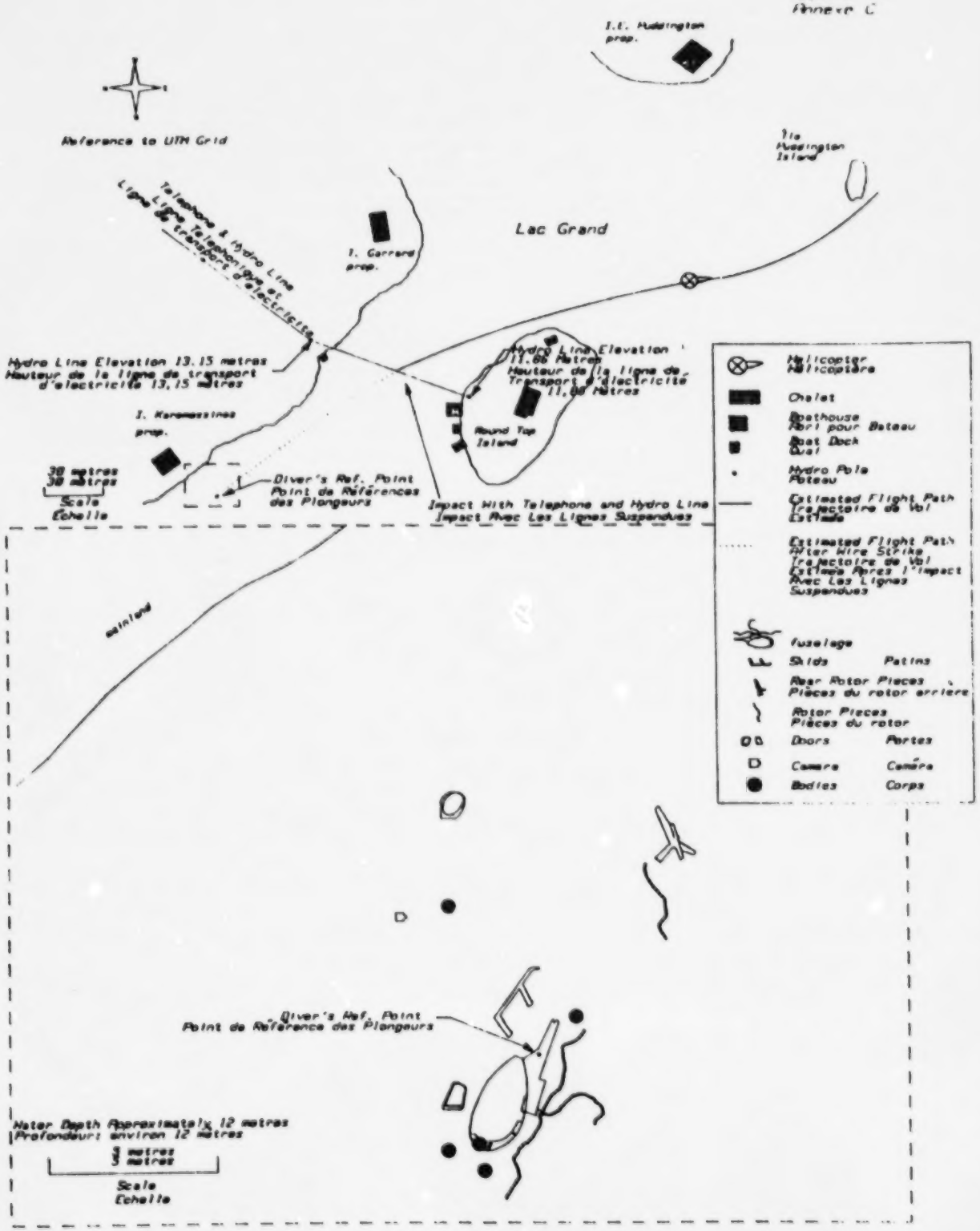



Arbitrary Sag On Telephone Line
Flèchissement Arbitraire de la Ligne de Téléphone
Helicopter Altitude Approx. ? Meters
Altitude de l'Hélicoptère : Environ ? Mètres

Detail of Impact With Wires
Détail de l'Impact Avec Les Lignes Suspendues

Note: This drawing is an approximation of the area and flight path
Remarque: Ce dessin est une approximation de la région et de la trajectoire de l'hélicoptère

Derived From Figure 3 of Engineering Project LP 89/87
Tiré de la Figure 3 du Projet d'Ingénierie LP 89/87



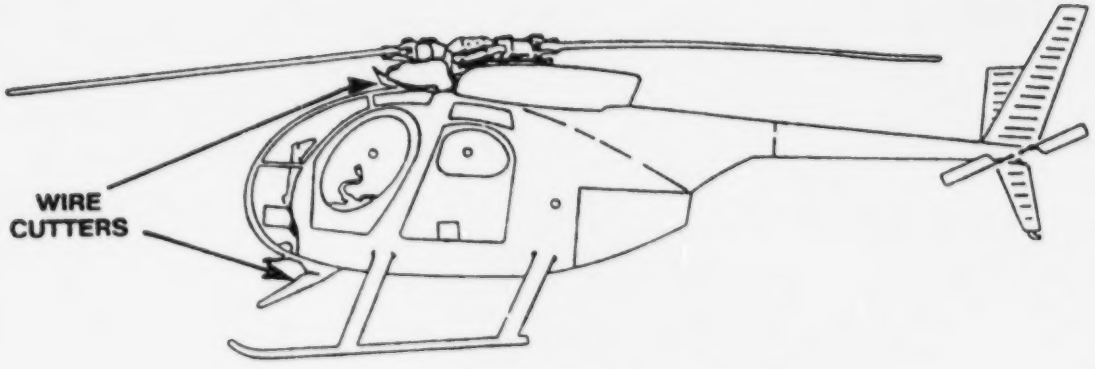
Detail of Wreckage Distribution
Plan de la distribution de l'épave

Note: This drawing is an approximation of the area and flight path

Remarque: Ce Dessin est une Approximation de la région et de la trajectoire de l'hélicoptère

Derived From Figure 2 of Engineering Project Lp 89/87
Tiré de la Figure 2 du Projet d'Ingénierie Lp 89/87

DETAIL OF WSPS INSTALLATION



WEIGHT AND CENTRE OF GRAVITY CALCULATION

The weight and centre of gravity were calculated as follows:

Item	Weight (lb)	Arm (in)	Moment (in-lb)
Helicopter (basic)	1,508.0	-	163,376.8
Pilot	185.0	73.5	13,597.5
Right front passenger	190.0	73.5	13,965.0
Centre front passenger	175.0	71.5	12,512.5
Left rear passenger	235.0	105.0	24,675.0
Right rear passenger	175.0	105.0	18,375.0
Camera, battery, and log book	25.0	73.5	1,837.5
Fuel*	350.0	97.1	34,000.0
Oil	8.0	135.6	1,085.0
Total	2,851.0		283,424.3

$$\text{Centre of Gravity} = \frac{\text{total moment}}{\text{total weight}}$$

$$= \frac{283,424.3 \text{ in-lb}}{2,851.0 \text{ lb}}$$

$$= 99.412 \text{ in}$$

* Fuel weight was calculated as follows: full fuel, 413 lb minus 63 lb which was the computed burn at 150 lb/hr for 25 minutes.

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 88/87 - Restoration, Information Transfer and Enhancement of Videotape Evidence;

LP 89/87 - (Developmental) Computer Drawing of Wreckage, Site Diagram, and Flight Path; and,

LP 90/87 - Freeze Drying of Aircraft Documents.

These reports are available upon request from the Canadian Aviation Safety Board.

GLOSSARY

agl	above ground level
ANO	Air Navigation Order
asl	above sea level
ATC	air traffic control
CASB	Canadian Aviation Safety Board
EDT	eastern daylight time
FAA	Federal Aviation Administration
G	load factor
hr	hour(s)
in	inch(es)
lat	latitude
lb	pound(s)
long	longitude
N	north
NWPA	Navigable Waters Protection Act
UTC	Coordinated Universal Time
W	west
WSPS	wire-strike protection system
°	degree(s)
'	minute(s)